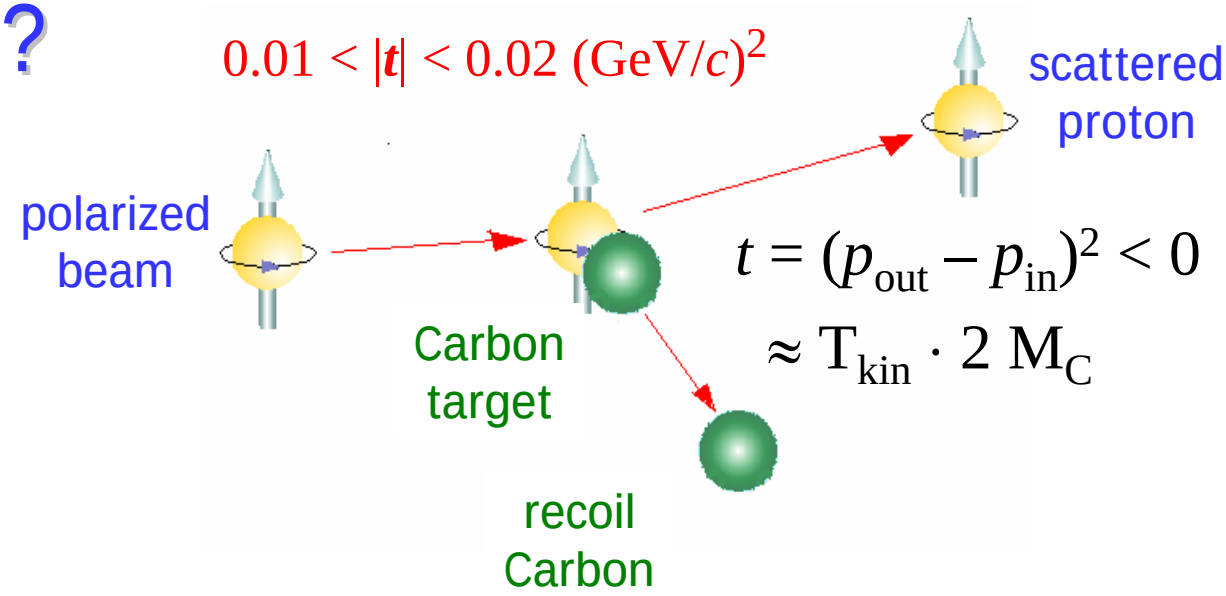
Polarimetry

1. Provide polarization measurements for accelerator

2. Provide polarization measurements for experiments

How It Works ?

$$P_B = -\frac{1}{A_N} \cdot \frac{N_{left} - N_{right}}{N_{left} + N_{right}}$$



Polarimetry:

Requires large F.o.M: A_N^2 x *rate* for fast measurement

(not at any price however, i.e. by increasing the rates)

small A_N ~ 1 % (far from ideal !)

⇒ requires large statistics > 10^7, for d P_B ~ few %

however too large rates (i.e. thick target, detector area, etc.)

⇒ occupancy and pileup

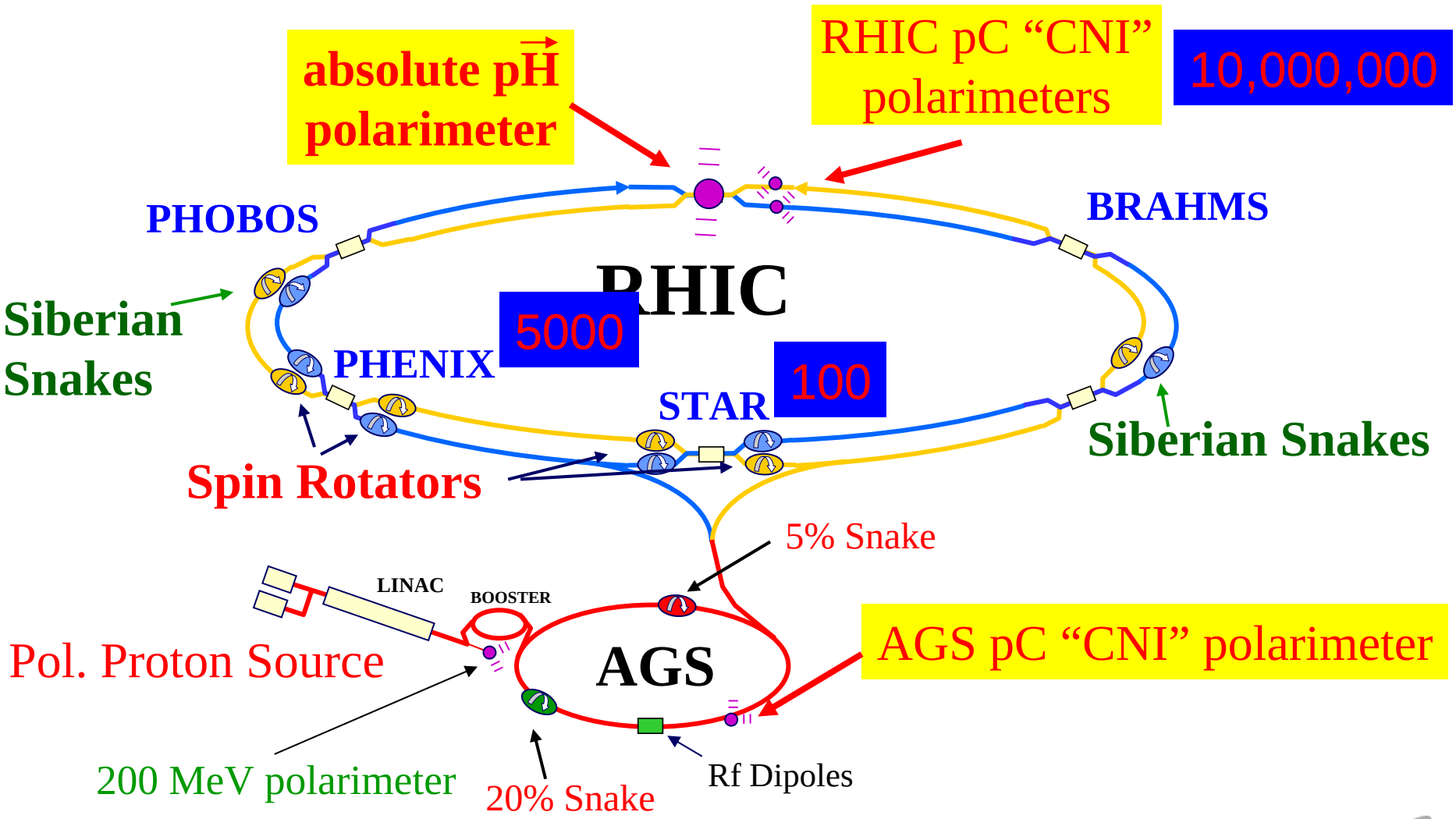
⇒ very difficult operation

⇒ corrections to measured asymmetries

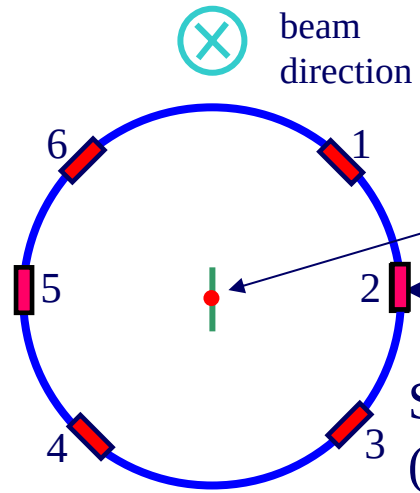
⇒ larger systematic uncertainty

RHIC Experiments

The polarimeters are experimental devices

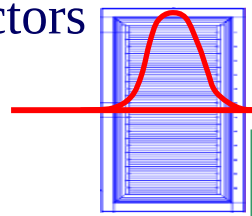


Setup for $\vec{p}C$ scattering – the RHIC polarimeters



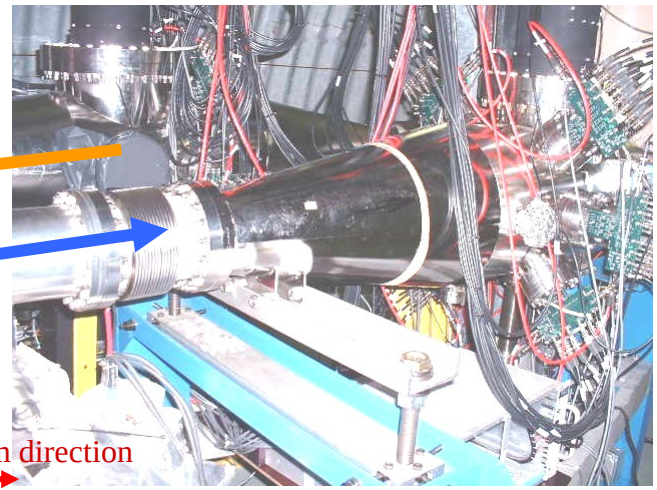
Ultra thin Carbon ribbon Target
(3.5μg/cm², 5μm wide)

Si strip detectors
(ToF, E_C)



all Si strips parallel to beam

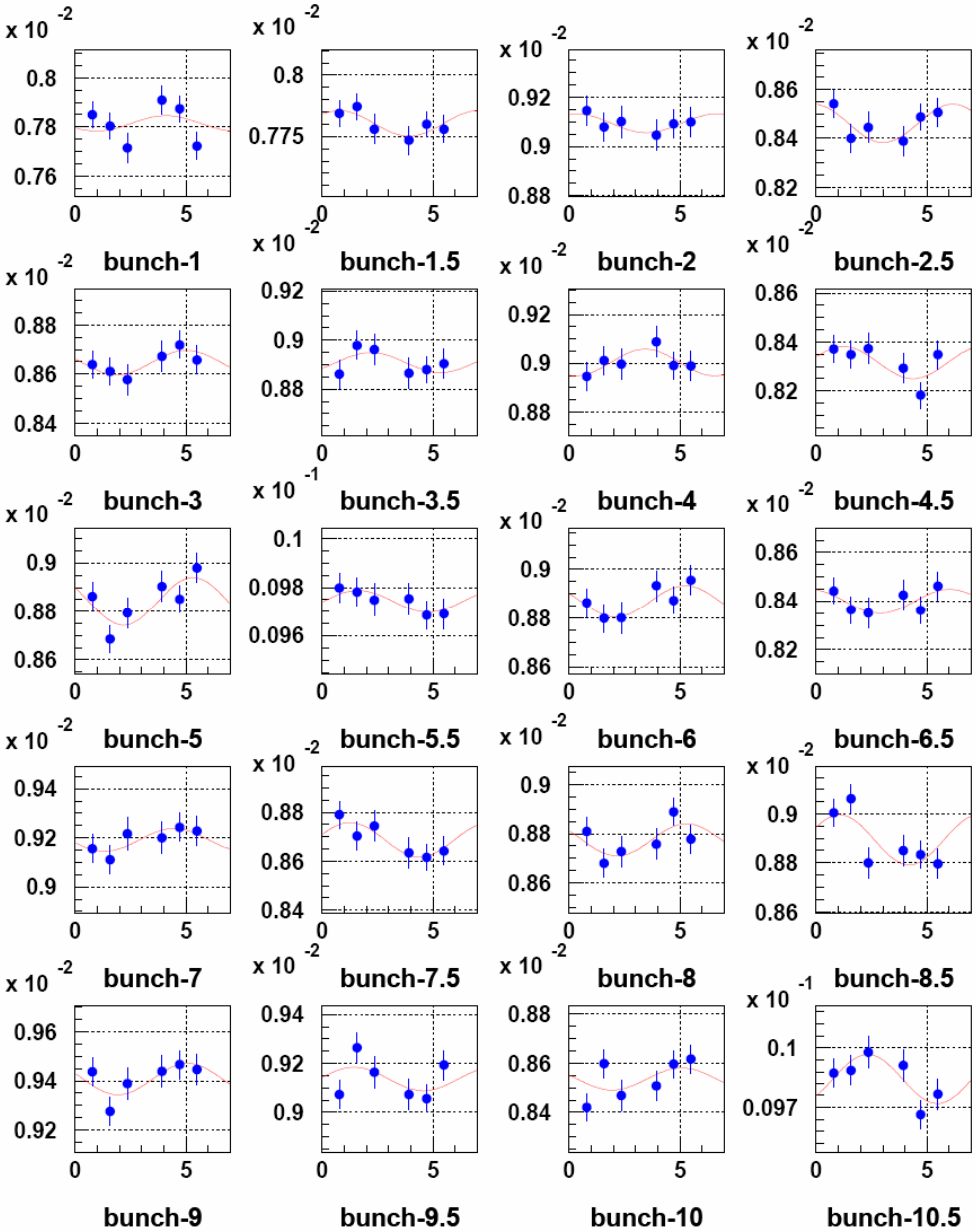
inside RHIC ring @IP12

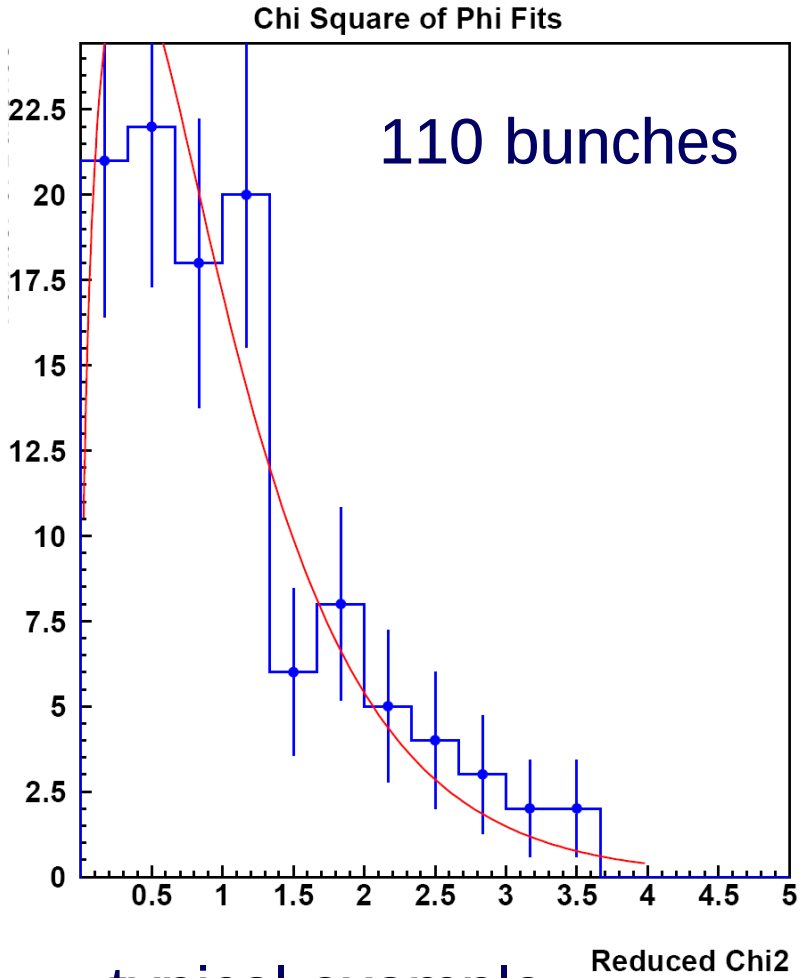


RHIC × 2 rings

- recoil carbon ions detected with Silicon strip detectors
- 2 × 72 channels read out with WFD (increased acceptance by 2)
- very large statistics per measurement (~ 20×10^6 events) allows detailed analysis
  - bunch by bunch analysis
  - channel by channel (each channel is an "independent polarimeter")
  - 45° detectors: sensitive to vertical and radial components of $\vec{P}_{beam}$
    → unphysical asymmetries

Bunch by Bunch





typical example

sometime even nicer than in textbooks

RY

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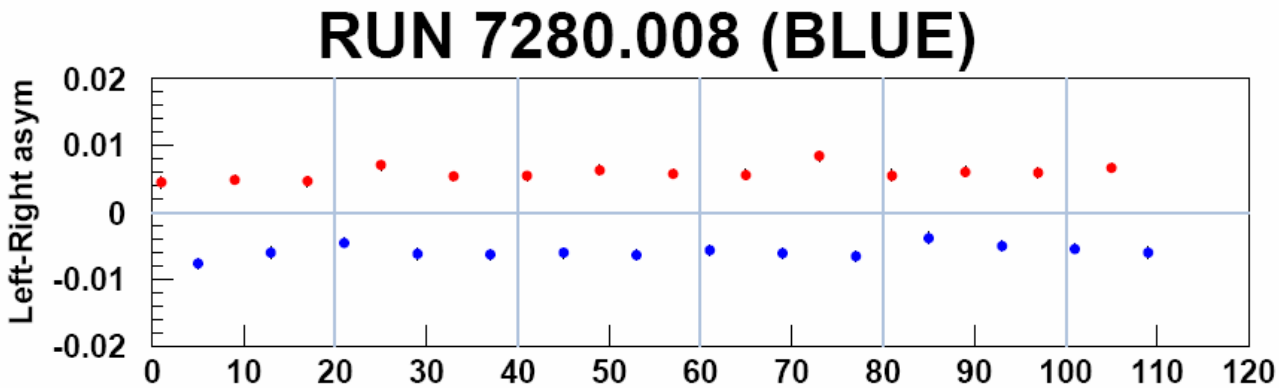
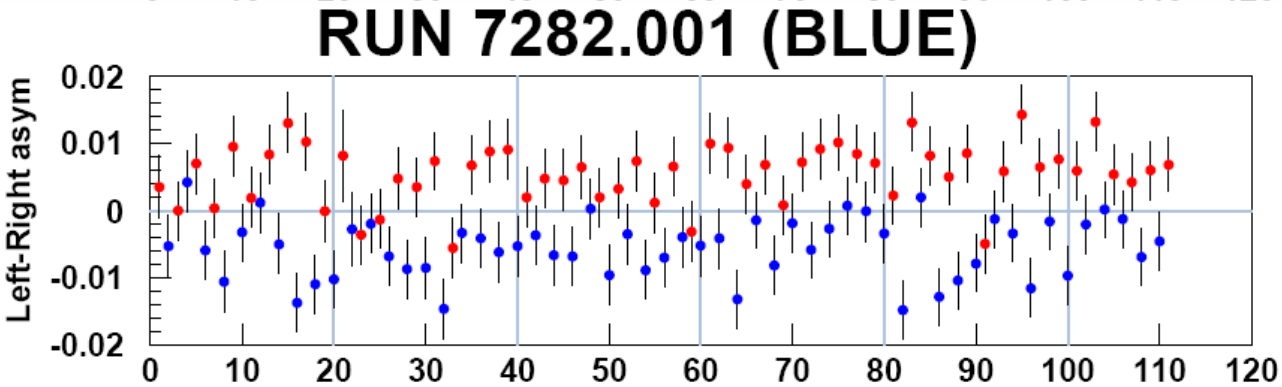
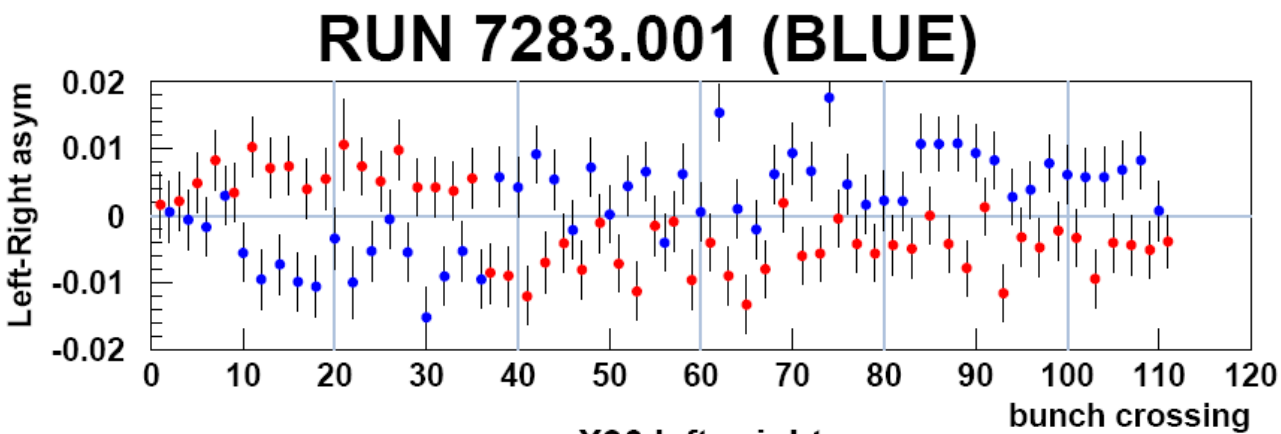
Bunch by Bunch



high statistics
28 bunches
@ injection

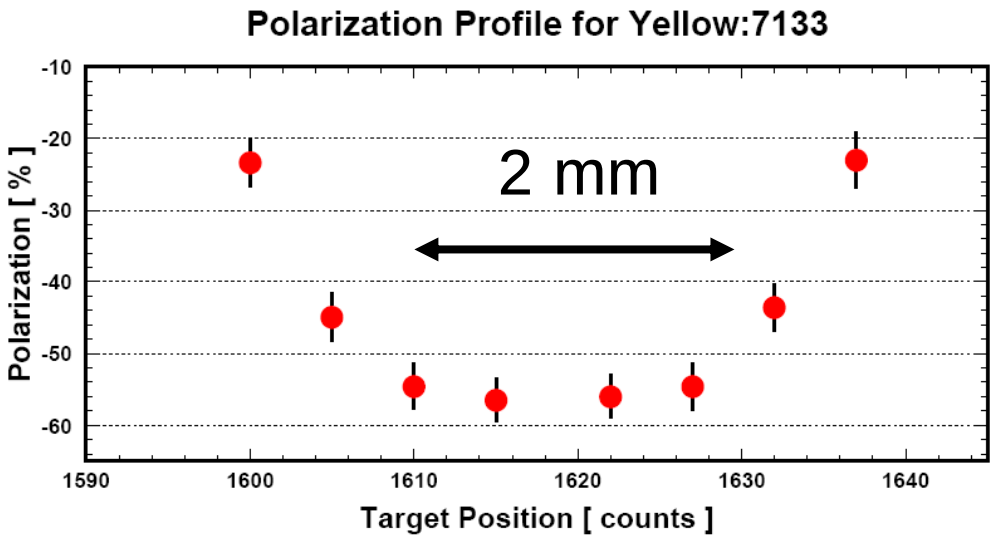


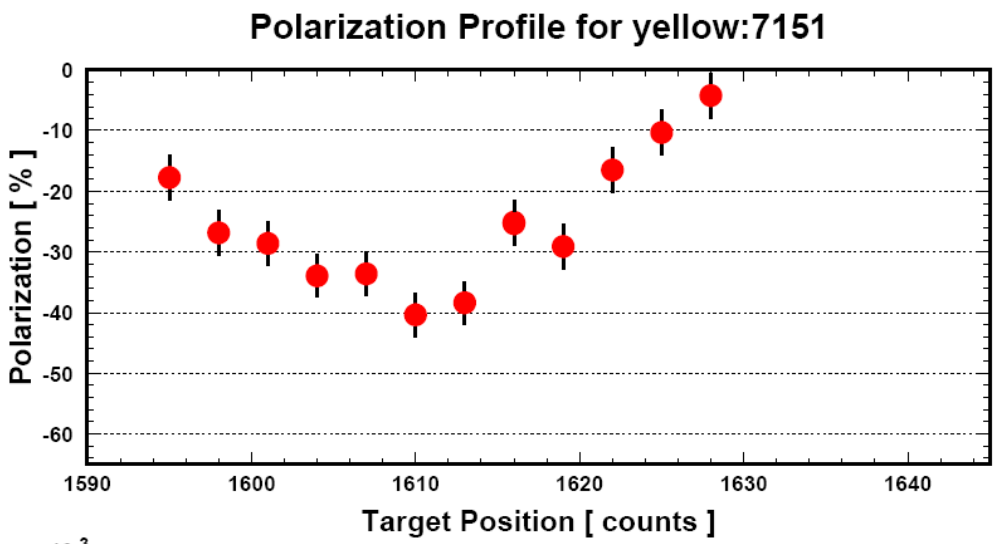
110 bunches
@ flattop
10^{11} p / bunch



110 bunches
@ flattop
with messed
spin pattern

Polarization Profiles ...





can or cannot
draw conclusions ?

needs systematic study:
beginning & end of store
vertical profiles
etc.

to avoid target location
dependencies,
sweep the target through
the beam,
however it doesn't work yet

From 2004 to 2005

- No more beam pickups
  - energy correction (almost) under control
  - we can work with 110 bunches
- Fast DAQ
  - USB Camac controllers > 20 MB / sec
  - readout for one measurements ~ few seconds
  - separate readout for Yellow and Blue
- New FrontEnd
  - Plug & Play
- Silicons
  - high quality ... (Inst. Div.)
- JET
  - measure Blue and Yellow beams

2005 Problems

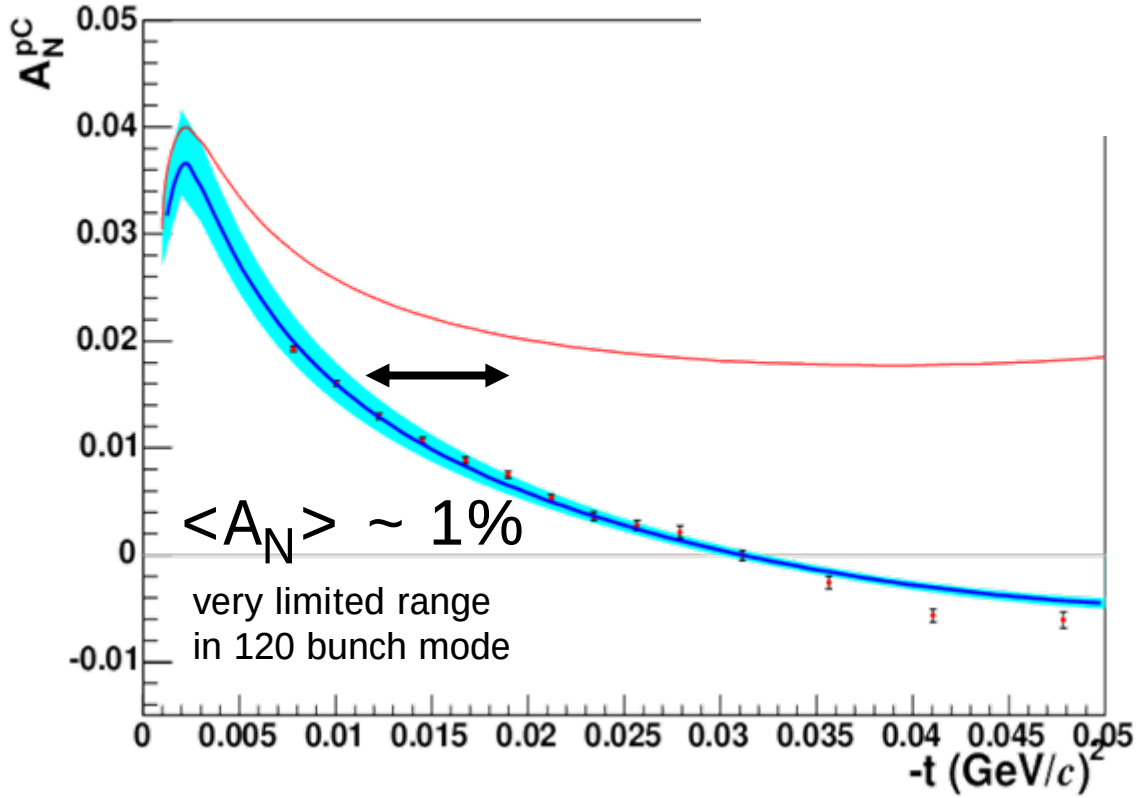
- Targets, Targets, and Targets again
  - Target quality: too thick ! 5μ x 3.5 μg vs. 70μ x 6 μg
  - Target mechanics: for instance alignment
  - Target controls: still not fully debugged nor fully operational
- Vacuum
  - Pressure increased by almost 2 orders of magnitude, very slow decay
  - outgasing tests started, need RGA at polarimeter chambers
- Commissioning
  - 2004: started the pp run with 6 “experts”
  - 2005: started with 3 “experts”, after 2 weeks only 2 @ BNL
    AGS + RHIC CNI + JET at the same time

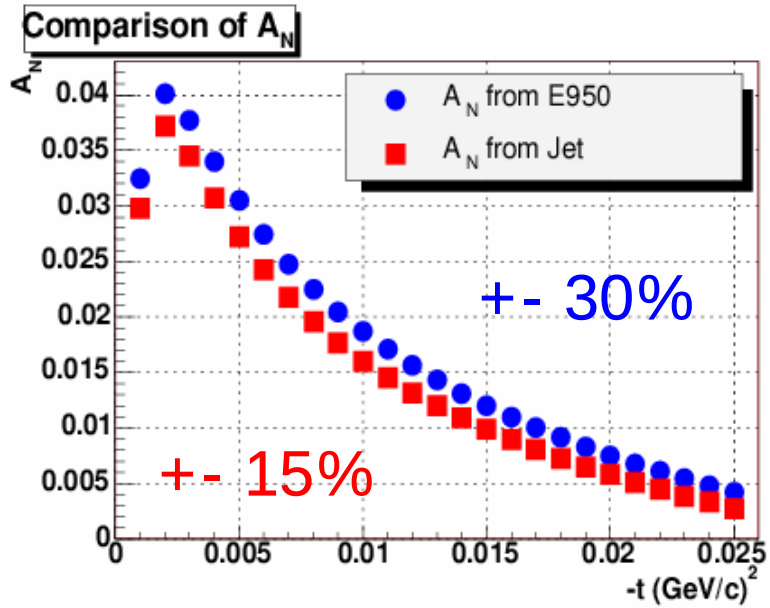
damaged yellow detectors during commissioning phase, had to replace
Set back commissioning clock by about 1 week

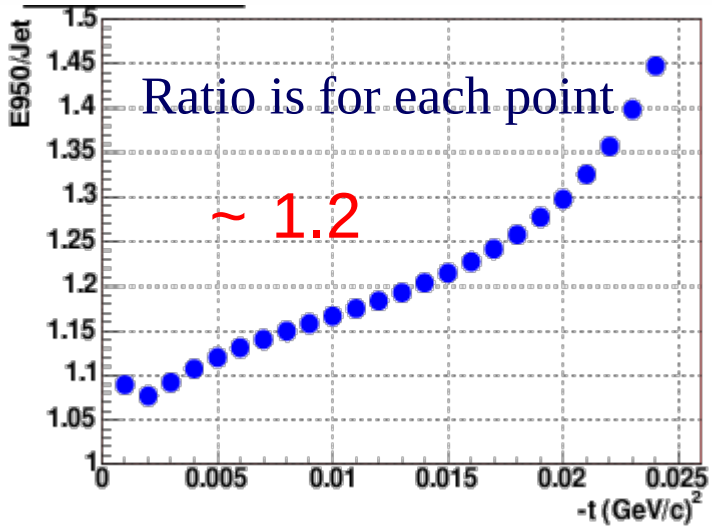
- Online software
  - based on “old” scalers mode (wanted to abandon already for this run)
  - in the beginning not correctly set
- Operations
  - by far more heavy than anticipated

100 GeV Calibration

based on 2004 JET run





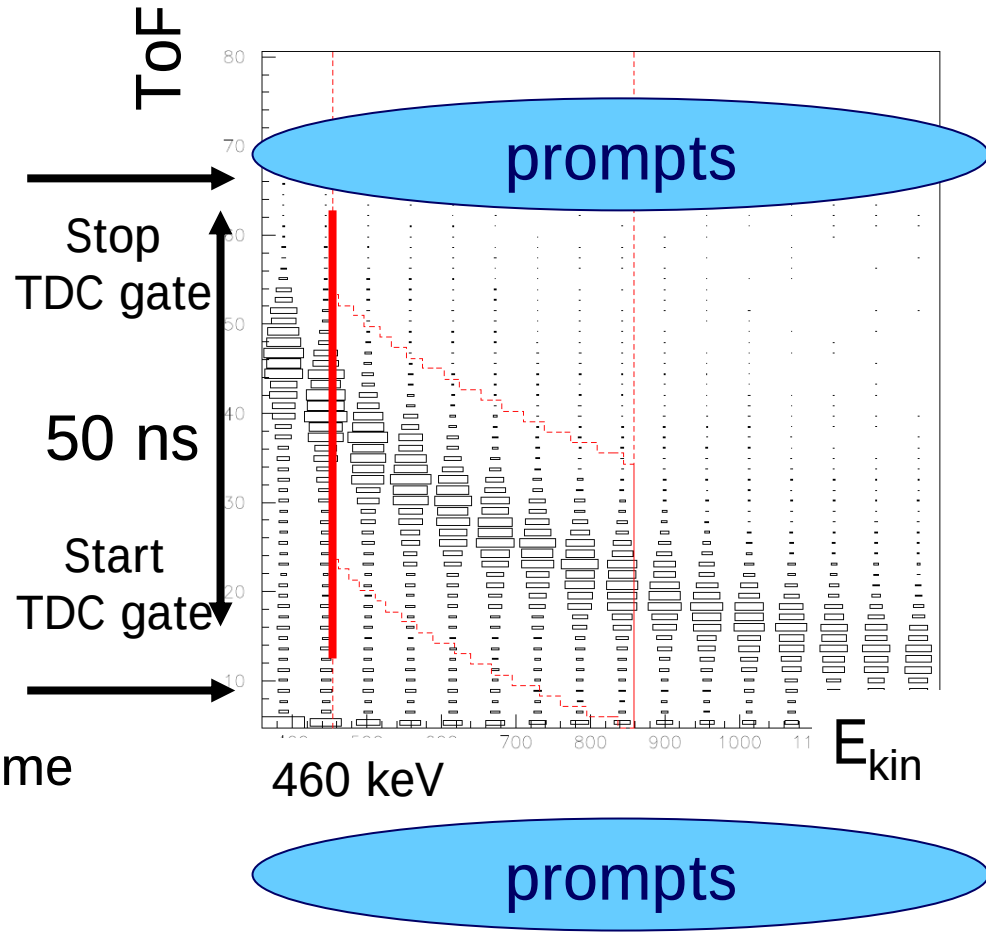


A_N (E950) = 1.2 x A_N (@100 GeV)
=> P_{Beam} ~ 20 % higher

120 Bunches

Run not under “ideal” conditions
Need additional development + address intensity issues

Operated in a very narrow energy range: longer measurement time for same statistics
With very tight TDC gates



It required significant commissioning time

Where is the problem ?

the signal must “decay” before the next bunch crossing to trigger and to avoid pileups (NB high rate!)
BW lost on signal cables (risetime 10 ns -> 20 ns + skin effects)
use fast shapers but with long tails (semi-gaussian)

Need:

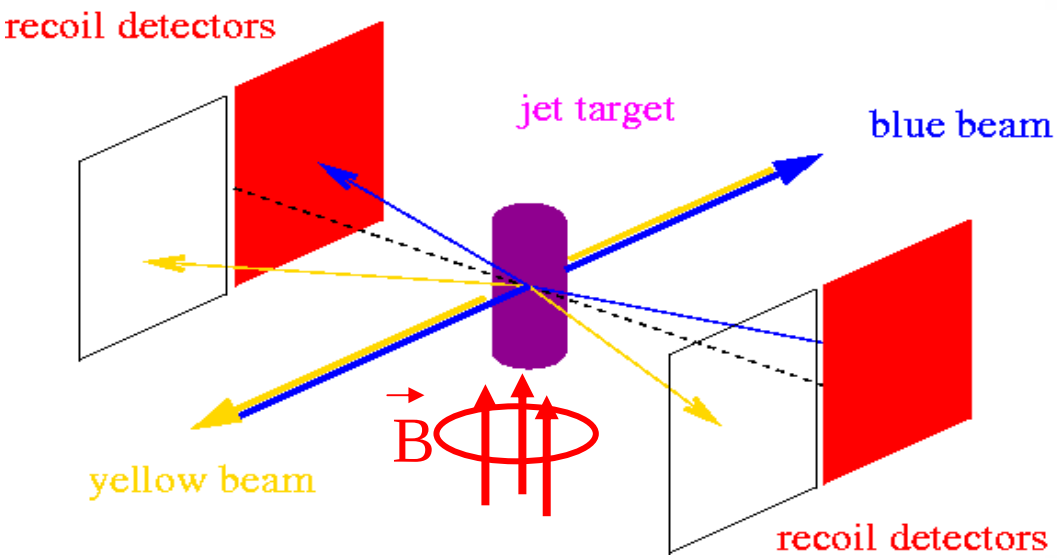
recable the polarimeter with broader BW cables
fast gaussian (symmetric) shapers with FWHM ~ 10 ns

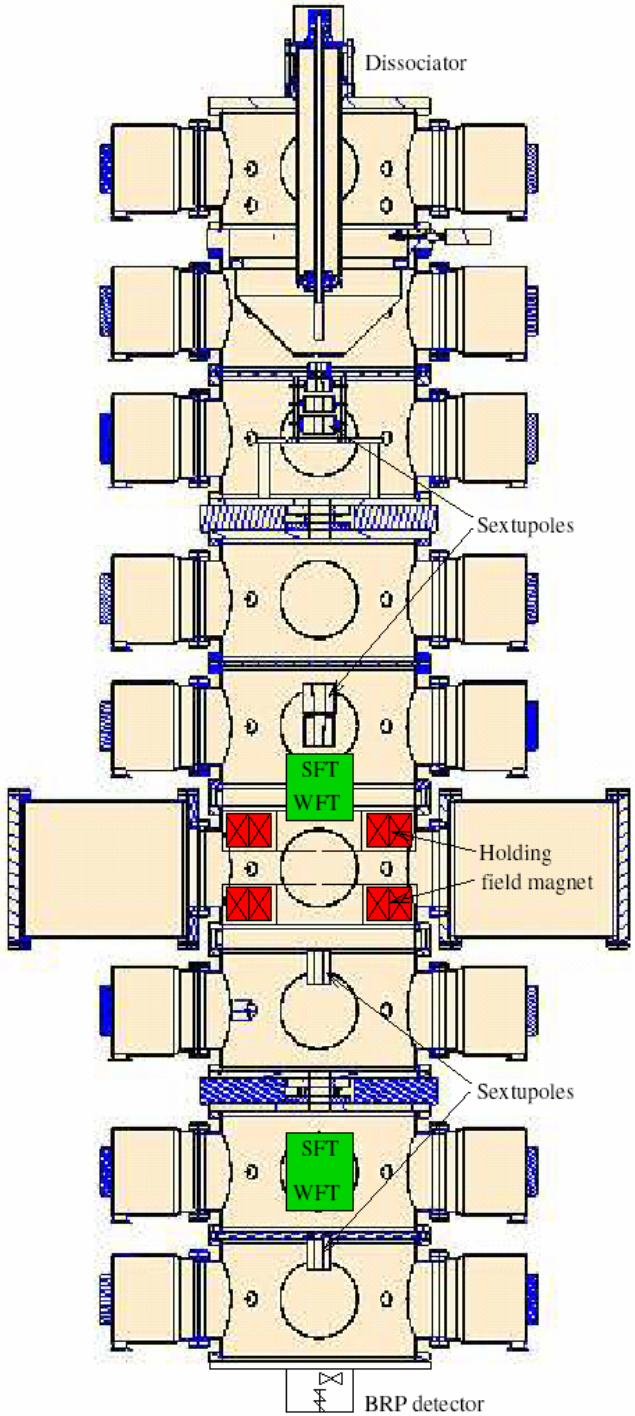
JET Target

$A_N^{beam}(t) = A_N^{target}(t)$

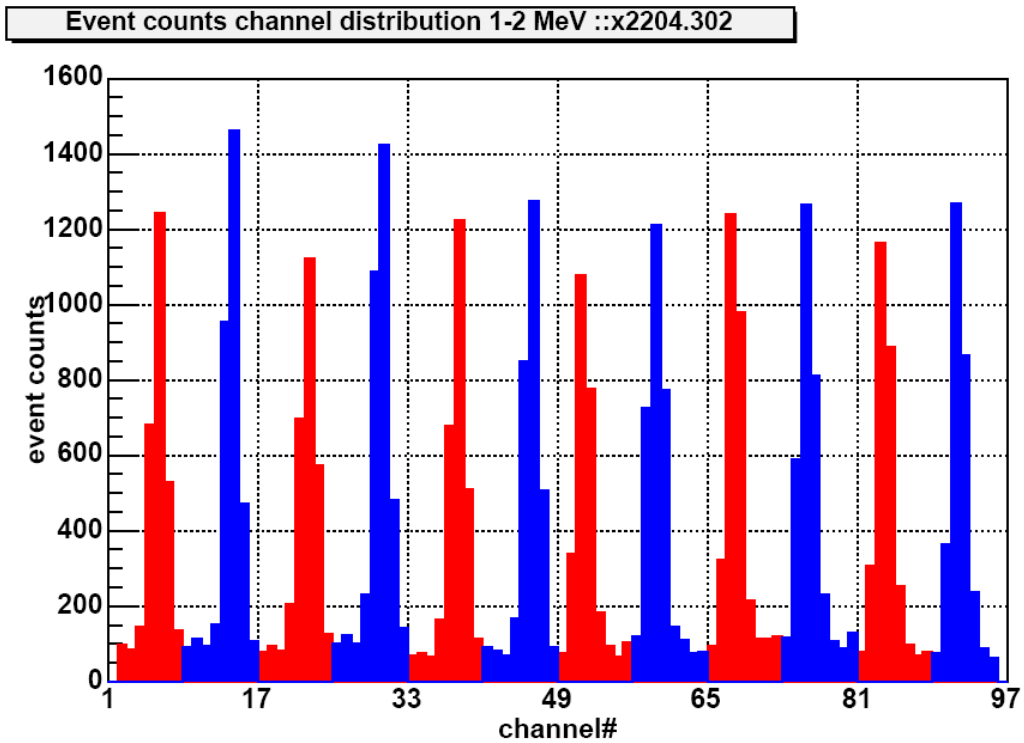
for elastic scattering only!

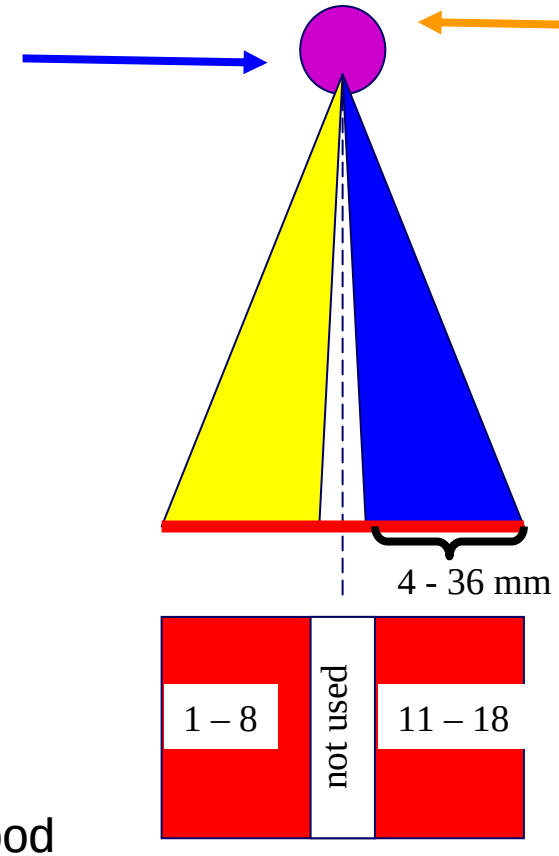
$P_{beam} = P_{target} \cdot \varepsilon_N^{beam} / \varepsilon_N^{target}$





JET: Elastic pp Events

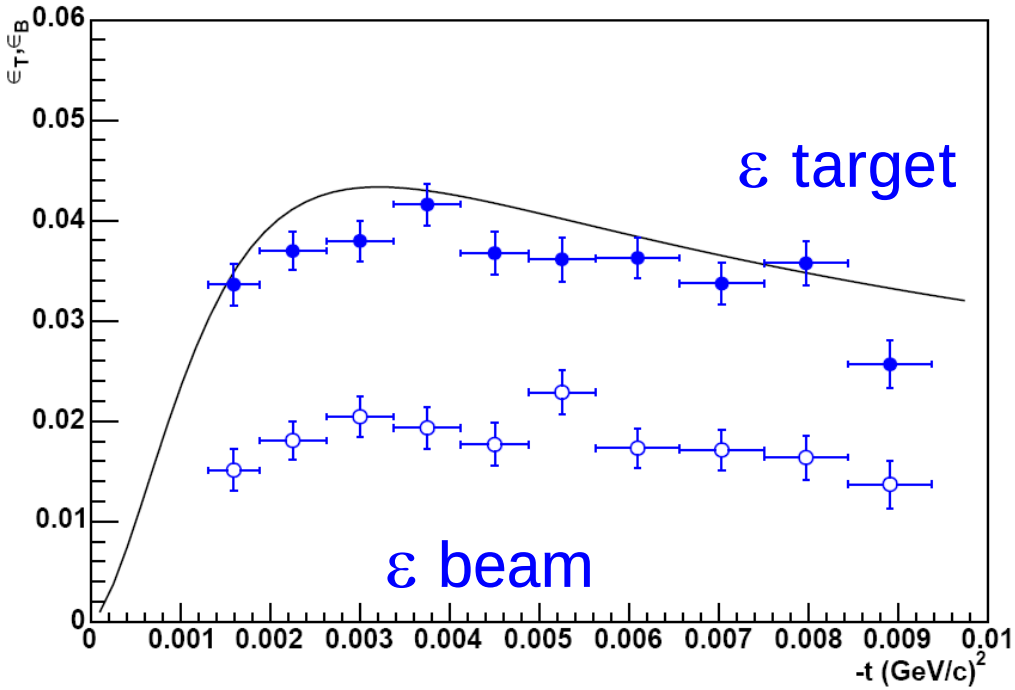




Backgrounds 2 x larger than in 2004; not fully understood
In principle could run with both beams at the same time, however decided to run with one beam at the time

Statistics: (04/20 – 06/07)
1,500 k events in Yellow
900 k events in Blue
10 % empty target runs (background studies)
1 – 2 MeV region

JET Asymmetries



... work in progress ...

"self calibrating"

"Target": ε_T – target asymmetry average over beam polarization

"Beam": ε_B – beam asymmetry average over target polarization

$$P_{Beam} = P_{Target} \cdot \frac{\varepsilon_{Beam}}{\varepsilon_{Target}}$$

$\langle P_{Beam} \rangle$ during the run ~ 0.5 (10% error, mainly from backgrounds)

Analysis

- MUST complete before next pp run
- Intermediate values sometime this summer ?

- Expect long and painful process (will not be a smooth ride!)
  - much more data than in the past
  - RHIC CNI: higher rates than expected
  - JET: 2 x higher backgrounds compared to 2004
- Finalize Energy Correction and Systematic issues

- NEED: 3 persons working 100% of their time on the analysis (RHIC CNI + JET) for 6 – 8 months

  So far only 1 available

For 2006 ...

- OPTION ZERO:
  do nothing; just basic maintenance

- MINIMAL:
  - high quality targets with enough spares + mechanics
  - target controls fully debugged and operational
    interface part of target controls directly to DAQ
  - solve vacuum issues
  - new shaping electronics (for 120 bunches)
  - high intensity studies on the bench
  - new ONLINE software: analysis closer to final
  - separate DAQ PCs for Blue and Yellow polarimeters

- MORE:
  - recable polarimeter with broader BW cables: att < 6 db/ 100m @ 400 MHz
  - silicon test facility
  - separate DAQ + WFDs for JET
  - computer controlled Power Supplies

Summary

- the polarimeters can be operated reliably

  however they require constant “expert” attention &

  cannot be left unattended !

- Operation + Analysis difficult, especially during a long run

  need more “experts” at work +

  reduce gap between online and final results

- targets are part of the polarimeters

  we all MUST do a better job next time

- expect $\Delta P_{Beam} / P_{Beam} \sim 6 - 8\ \%$

- additional developments for 120 bunch operation and high intensity

- development + readiness: two separate tasks running in parallel